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Environmental Public Health Tracking/ Surveillance in Canada: A Commentary

Suivi et surveillance en matière de santé
environnementale et publique au Canada :
observations



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Abstract

Although public debate in Canada about climate change and air pollution is louder than ever, the state of the environment remains a relatively neglected determinant of health, and environmental public health infrastructure and programs are poorly developed. Health Canada has only recently begun to develop a national environmental public health tracking or surveillance system. The authors review progress on environmental public health tracking in other jurisdictions and suggest a strategic approach to the development of a coherent national system of sensitive, targeted surveillance indicators for environmental health by addressing the following questions: Which environmental hazards and exposures, and which health effects along the continuum from “release” to “health effect,” should be tracked? Which indicators are scientifically robust and practical for tracking environmental health problems in Canada?

Résumé

Bien qu'au Canada, le débat public sur le changement climatique et la pollution de l'air soit plus vif que jamais, l'état de l'environnement demeure un déterminant de la santé relativement négligé. L'infrastructure et les programmes en matière de santé environnementale et publique sont peu développés. Ce n'est que récemment que Santé Canada a commencé à élaborer un système national de suivi, ou surveillance, de la santé environnementale et publique. Les auteurs examinent, auprès d'autres autorités administratives, les progrès accomplis en matière de suivi de la santé environnementale et publique. Ils proposent une stratégie de développement pour un système national cohérent d'indicateurs significatifs et ciblés, au moyen des questions suivantes : Quels sont les risques environnementaux et quels sont les effets sur la santé (allant de l'émission de polluants aux effets sur la santé) qui doivent être suivis? Quels indicateurs sont scientifiquement valides et applicables face aux problèmes de santé environnementale au Canada?



“Twenty-two-month old Kody woke up violently ill, his diaper stained blood red. ... Two-and-a-half-year-old Mary Rose Raymond, who lived in nearby Hanover, had died of *E. coli* bacterial poisoning. ... Betty Trushinski was admitted to hospital and soon transferred to London. ... Two days later, she began to have difficulty breathing. Within another two days, the fifty-six-year-old was dead: her brain, lungs, liver, kidneys and intestines destroyed by the vicious verotoxin produced by *E. coli* 0157:H7. ... (Perkel 2002)

IN THE WAKE OF THE 2002 TAINTED-WATER SCANDAL IN WALKERTON, Ontario, new laws were developed to protect the province's water supply. But without a comprehensive plan for monitoring and consequent treatment and enforcement, no law or commitment is worthwhile. The connections between such local health tragedies as Walkerton's and global economic and environmental change also demand attention. Indeed, Canada is now in the throes of a national debate about our Kyoto commitments. However, public health professionals sense a deeper issue: even if we did have serious Kyoto-type targets, would our existing environmental health surveillance systems be up to the task of demonstrating progress – or a lack thereof – in reducing the health consequences of environmental degradation?

This commentary reviews national and international progress to date on this issue and suggests a strategic approach to developing a coherent system of sensitive, targeted surveillance indicators for environmental health in Canada by addressing two questions. First, which environmental hazards and exposures, and which health effects along the continuum from “release” to “health effect,” should be tracked? Secondly, which indicators are scientifically robust and practical for environmental health problems in Canada?

Environmental public health tracking/surveillance (hereafter referred to as tracking) is not as well developed as surveillance in other health and safety domains in Canada. To address this deficit, the Federal/Provincial/Territorial Committee on Health and the Environment established the Tracking/Surveillance Task Group (2006) to develop a Health and Environment Tracking/Surveillance System in Canada.

Public health surveillance involves not only the ongoing systematic collection of data on specific health events affecting a population, but also the analysis and interpretation of those data and, importantly, the effective communication of the data to public health professionals and policy makers (Thacker and Stroup 1994). Environmental health is an important but neglected public health issue in Canada. It accounts for approximately 16% of the total burden of disease, in disability-adjusted life years (DALY), in developed countries, including Canada. Much of this environmentally related disease burden is preventable (WHO 2006).

Examples of Environmental Health Surveillance Systems

Environmental health surveillance systems have been recently developed in the United States, Europe and Quebec. The strengths and weaknesses of these systems are described in Table 1.

In the United States, the Pew Commission was mandated in the 1990s to report on the need for surveillance. Its report (Pew Environmental Health Commission 2000) was a first attempt at defining the scope of a proposed tracking system. The commission identified a lack of critical knowledge in environmental public health, the

so-called environmental health gap. It recommended the establishment of a National Environmental Health Tracking Program, which was launched in 2002, as a program within the Centers for Disease Control (CDC), in concert with the Environmental Protection Agency, the National Aeronautics and Space Administration and state partners (McGeehin et al. 2004). The goal of the program is to allow the federal, state and local governments to “monitor and distribute information about environmental hazards and disease trends, to advance research on possible linkages between environmental hazards and disease, and to develop, implement and evaluate regulatory and public health actions to prevent or control environment-related diseases” (CDC 2006a).

TABLE 1. CDC, EU and Quebec environmental health tracking systems: strengths and weaknesses

Initiative	Strengths	Weaknesses	Indicators
CDC Centers for Disease Prevention and Control (CDC 2006b)	<ol style="list-style-type: none"> Partnership with federal, state and local government agencies, academic and community groups, healthcare organizations Strong stakeholder input Pilot projects well coordinated 	<ol style="list-style-type: none"> Varying levels of state readiness Early in development: <ul style="list-style-type: none"> First national report, 2008 Network launch, 2008 	Topics Air, ambient (outdoor) Air, indoor Disasters Lead (Pb) Noise Pesticides Sentinel events Sun and ultraviolet Toxics and waste Water, ambient Water, drinking Indicator Types Hazard Exposure Health effect Intervention
EU European Union (WHO Europe 2004)	<ol style="list-style-type: none"> Includes upstream driving forces Includes home, work and ambient exposures Includes population exposure and health impact assessment (air quality, noise) Linked to health-based policy action programs (NEHAPs) Developing a children's environment and health indicator set 	<ol style="list-style-type: none"> Diverse data systems across EU Gaps in survey and biomonitoring data Still to define outputs (printed reports and Web-based data) 	160 indicators proposed in: Air quality Housing Noise Traffic accidents Water and sanitation Food safety Chemical emergencies Radiation Workplace

Environmental Public Health Tracking/Surveillance in Canada: A Commentary

TABLE 1. Continued

Quebec (Institut national de santé publique du Québec 2006)	<ol style="list-style-type: none"> 1. Common surveillance re: occupational and infectious diseases within Ministry of Health and Social Services 2. Annual reporting 3. Research in environmental health surveillance since 1997 with Geomatics for Informed Decisions National Centre of Excellence (GEOIDE NCE) 4. Strong public health surveillance mandate in 2001 Public Health Law 5. Stable funding 6. Strong Quebec Public Health Institute [Institut national de santé publique du Québec (INSPQ)] 	<ol style="list-style-type: none"> 1. Not all indicators completed 2. Gaps in data for some proposed indicators 	<p>Twenty-six of 41 indicators reported.</p> <p>Environmental Indicators:</p> <ul style="list-style-type: none"> Recreational water quality (beaches) Drinking water quality Boil-water advisories Waste water treatment Air pollution Environmental tobacco smoke exposure <p>Health-Based Indicators:</p> <ul style="list-style-type: none"> Carbon monoxide and other poisonings notification rates Allergic rhinitis prevalence Cancers of interest for environmental health Hospitalization/mortality rates for diagnoses linked to environmental hazards <p>Proposed Indicators:</p> <ul style="list-style-type: none"> Noise Indoor air Pesticides Climate change (mortality for heat waves, morbidity and mortality linked to extreme weather events)
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California, one of the more advanced state partners in this program, established the California Environmental Health Tracking Program in 2002 (California Policy Research Centre 2004a; EHIB 2002). Initial development was guided by a report, *Strategies for Establishing an Environmental Health Surveillance System in California* (2004a,b), which defined the need for and goals of environmental health tracking in the state and reported on current knowledge about environmentally related diseases and their costs. The report listed the diseases, environmental hazards and exposures that should be tracked in California, and described community information needs as well as ethical, legal and policy issues. The initial phase of the program, funded by CDC, has focused on three goals:

1. developing the technology infrastructure, including projects on geocoding, pesticide mapping and air pollution from traffic mapping;
2. improving data availability and utility; and
3. promoting knowledge translation for practice and policy (California Policy Research Centre 2004b).

The World Health Organization (WHO) in Europe began developing an Environmental Health Information System (EHIS) in 1999 within the larger system of European Community Health Indicators (ECHI). EHIS is now being developed into a pan-European system, and a core set of environmental health indicators for Europe has been reported (WHO Europe 2004).

In Quebec, a common surveillance plan, including environmental health, occupational health and infectious diseases, was established under the Ministère de la santé et des services sociaux (MSSS), and is centralized within the Public Health Institute. Indicators are chosen by expert consensus in accordance with the Public Health Program objectives, 2003–2012 (MSSS 2003). Currently, 26 of the 41 environmental health indicators are reported, 17 related to exposures (environmental data) and nine with health data (Comité d'éthique de santé publique du Québec 2004).

While these three systems differ in terms of stage of development and comprehensiveness, they point to the recognition that environmental health in the public domain requires more attention to protect the health of populations.

Elements of an Environmental Public Health Tracking Program for Canada?

Environmental health can be very broad, including such issues as the overall “health of the planet” (including climate change), sustainable development and the built environment, or it can focus on specific, non-communicable environmental hazards: chemical, physical and biological. The terms need to be clearly defined so as to be manageable and relevant to policy making and action.

The field of environmental health is a complex arena. The associations between environmental hazards and health span different sectors and disciplines, from engineering and toxicology to epidemiology. Hence, environmental health tracking requires integration of data sets from many different sectors and disciplines. The science contains many uncertainties. The available evidence, besides that from toxicological studies, tends to derive from observational epidemiological studies. These provide evidence of association, but frequently fall short of meeting standard scientific criteria for causation in linking environmental hazards with health outcomes. In some areas the evidence is stronger (e.g., air pollution and health), but there are many areas of controversy (e.g., pesticides and health). The science is further complicated by such issues as multiple exposures; low-dose, long-term exposures; long latency periods; and genetic–environmental interactions. Furthermore, there are many gaps in the data, especially in terms of exposure, as discussed later. This is difficult terrain for any environmental public health tracking system.

What Categories of Information Should Be Tracked?

Thacker et al. (1996) proposed three categories of surveillance information: hazard surveillance, exposure surveillance and health outcome surveillance. The importance of linking environmental health surveillance with policy and action has led to the addition of a fourth category of information: the assessment of policy interventions. Corvalan and colleagues (1999) argue in favour of including “upstream” driving forces such as economic changes (in production and consumption, poverty), social trends (population growth and urbanization) and technological factors that create pressures affecting the state of the environment. As indicators of environmental public health, these are in most situations impractical and non-specific to the hazards. Although these factors are important to policy analysis and intervention, they have not been included in the CDC or Quebec tracking systems, are not prominent in the EU tracking systems and are not addressed in this commentary.

To illustrate this point further, we have chosen particulate air pollution (PM_{2.5}) as a “worked example.” Table 2 illustrates the causal pathway from hazard to exposure to illness. First, the hazard is released into the environment, in this case particulate matter from motor vehicles, power generation or wood smoke. Then individuals and population groups are exposed by breathing the polluted air. Finally, some of the exposed population will develop health effects. PM_{2.5} is chosen as an example because (a) the evidence for association between exposure to the hazard, PM_{2.5}, and the health effects discussed is considered strong, (b) the burden of illness is large (Ontario Medical Association 2005) and (c) there are effective policy interventions, such as reducing traffic in urban areas or reducing coal-burning power generation. It is estimated that a one-unit reduction in sulphate air pollution in Canada would lead to a mean annual increase of quality-adjusted life years (QALY) of almost 21,000 (Coyle et al. 2003).

Tracking hazards

Hazards are chemicals (e.g., pesticides, lead, particulates), physical agents (e.g., ionizing and non-ionizing radiation, noise and vibration) and biological toxins (e.g., water-borne pathogens) that are present in the environment and that have known or potential impacts on human health (California Policy Research Centre 2004a). Relevant data might include the amount of hazard produced, sold, used or released, or concentrations in the environmental media (air, food, soil and dust, water) and consumer products. Hazard tracking data sets in ministries of the environment and agencies responsible for transport, labour, agriculture, food and other areas were developed for the purpose of monitoring environmental quality and compliance with regulatory standards, and are not oriented towards health outcomes. Integration of these environmental data sets with health outcome data would present significant

TABLE 2. PM2.5 measures of air pollution in the causal pathway as a worked example of this approach

Hazard surveillance	Exposure surveillance	Health effect surveillance	Intervention options
Ambient levels of PM2.5 ↑ Routinely and continuously monitored in real time in many locations ↓ Needs geographically denser monitoring sites or GIS modelling ↑ The quality of the data is excellent and assured, and the data source is valid, reliable and sensitive Air Quality Health Indicator (AQHI) ↑ Health risk based ↑ A single indicator synthesizing many air pollutants and health effects	Ambient levels shown to be good surrogate for personal exposure ↓ Many micro-environments and complex PM chemistry complicate picture	Hospitalization – Respiratory and Cardiac Mortality – Respiratory and Cardiac ER visits – Respiratory ↑ Data routinely collected by CIHI; can be analyzed ↓ Needs complex time series methods ↓ Lacks specificity; effects related to co-morbidity/age ↓ “Harvesting” (displacement) effect on mortality* ↓ Health outcomes are the tip of the pyramid, so the full extent of health effects is not demonstrated	↑ Can be promptly acted upon, with public health benefit (e.g., air quality advisories to reduce exposure, and industrial shutdowns to reduce emissions) ↑ Useful to promote long-term policy re: power generation, transportation, etc. ↑ Can be used to assess interventions ↓ Complex health messaging with advisories

Note: Critical commentary is that of the authors, with ↑ indicating a positive attribute, and ↓ indicating a negative attribute.

* “Harvesting” refers to deaths precipitated by a pollution incident that would have occurred within a short period of time in the absence of the high-pollution event. (Smith 2003).

* Smith 2003

challenges in terms of standardization, in that the data sets were collected for different purposes and may use different standards for collection. There will also be problems in integrating data in terms of differences in spatial and temporal determinants. Table 3 presents a selection of sources of data related to air pollution. This brief list illustrates the numerous data sources; a comprehensive review is beyond the scope of this paper. Similarly, there are multiple data sources for water, food and chemical hazards. For example, the Healthy Environments and Consumer Safety Branch (HECSB) Surveillance Working Group and the Centre for Surveillance Coordination of Health Canada maintains an inventory of federal/provincial/territorial environmental and occupational health data sources and surveillance activities, which lists 15 drinking water quality and eight food contamination data sites (Health Canada, Healthy Environments and Consumer Safety Branch 2004). Some of these databases are required under federal/provincial/territorial, bi-national or international agreements.

Tracking exposures

Exposure is the contact between a hazard in the environment and an individual, group or population by inhalation, ingestion, dermal contact or, for a foetus, through the

placenta. There is generally a lack of detailed information about human exposure over the life course, and this is the weakest, although perhaps the most important, link in the information describing the hazard-exposure-disease pathway (Mather et al. 2004). In the absence of direct measurement of exposure, indirect data on exposure can be derived from measuring environmental concentrations of substances and modelling exposure. However, indirect exposures do not account for variations in exposure due to individual behaviour. For example, an individual exercising outdoors will be exposed to more PM_{2.5} – because of faster, deeper breathing – than someone sitting quietly.

TABLE 3. Air hazard data sources

Data source	Jurisdiction	Hazards monitored
National Pollutant Release Inventory (NPRI)	Environment Canada Regulated under Canadian Environmental Protection Agency (1999)	Release and transfer of key industrial pollutants
Criteria Air Contaminant (CAC) emissions inventory	Environment Canada (reporting requirements under ozone annex to Canada – US Air Quality Agreement)	Selected air pollutants: particulate matter, nitrogen dioxide (NO ₂), volatile organic compounds, carbon monoxide, ammonia
National Air Pollution Surveillance (NAPS) Network	Environment Canada and provinces/territories (gazetted memorandum of understanding)	Ambient air pollution in urban centres
Canadian Air and Precipitation Monitoring Network (CAPMoN)	Environment Canada and provinces/territories	Selected air pollutants and acid rain; spatial and temporal patterns
Integrated Atmospheric Deposition Network (IADN)	Environment Canada and US Environmental Protection Agency (Annex 15 of the <i>Great Lakes Water Quality Agreement</i>)	Priority toxic chemicals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, mercury; in air and precipitation in the Great Lakes region
Canadian Atmospheric Mercury Measurement Network (CAMNet)	Environment Canada	Mercury
CORE Network Database	Environment Canada	Atmospheric chemicals and radiation
Air Quality Forecasts and Advisories	Environment Canada/provincial level	Selected air pollutants
Georgia Basin – Puget Sound International Airshed Strategy	Health Canada, British Columbia, Washington state	Air quality conditions by postal code

Two other issues further complicate exposure tracking. Firstly, there are “critical windows” in development during which the human body or organs are more susceptible to insult from exposures, especially for foetuses and children. Secondly, people are frequently exposed to mixtures of chemicals or other factors, with synergistic effects.

Direct information on exposure is gathered on a limited scale in research programs, for example, direct measurement of personal exposure to air pollutants by research subjects wearing personal exposure devices. Biomonitoring, which directly measures human exposure to toxic substances in the environment by measuring the substances or their metabolites in human specimens, such as blood, urine or hair, is a recent development in terms of surveillance, and the data to date from Europe and the United States, and from the Canadian Northern Contaminants Program, are limited. The Canadian Health Measures Survey will include biomonitoring in 2007–2009, but there is no current commitment to ongoing surveillance (Health Canada 2006a). Although biomonitoring holds promise, it is expensive and limited in scope, and modelling will remain an important source of exposure information.

Tracking selected health outcomes

Tracking of non-communicable diseases, and especially health status indicators related to environmental exposures, is limited in Canada (PHAC 2005). Although we have comprehensive data on the use of many healthcare services in the provinces and territories, the data sets are not standardized, easily linked or easily accessible, and the information is frequently difficult to interpret owing to (a) non-specificity of many health outcomes for their putative causal relationship with environmental hazards and (b) variable data quality.

Certain groups in our society are more vulnerable to environmental influences on their health, including children, northern communities, people living in poverty and those with pre-existing chronic diseases. Special consideration should be given to tracking environmental health in these “at-risk” groups, as sentinel indicators (Gosselin and Furgal 2002).

Tracking evaluation of interventions

The ultimate goal of any environmental public health tracking system is the implementation of healthy public policies and programs that prevent or reduce an environmental hazard, exposure or health effect. The science–policy interface is complicated, with scientific evidence contributing to the legitimacy of policy directions and to the rational formulation of policy in the face of political, economic and social pressures in the policy process (Aron and Zimmerman 2002). A tracking system must generate indicators and reports that communicate effectively in the policy arena. Measurement of indicators over time is important in monitoring the effectiveness of public health interventions, to provide the required feedback to the policy process (Corvalan et al. 1999; Briggs 1996; Kyle et al. 2006; Eyles and Furgal 2002).

Indicators

The number of potential indicators reflecting the four categories described above is enormous. There is a rich literature regarding the selection of environmental health indicators (Corvalan et al. 1999; CDC 2006b; Eyles and Furgal 2002; WHO Europe 2004). Environmental health indicators need to be scientifically sound, practical and usable.

- *Scientific criteria* include validity, reliability and representativeness of data. Also important is the evidence base for causation, as opposed to mere association or linkage, between environmental hazard or exposure and the health outcome of concern.
- *Practical criteria* include availability of data, ability to track the data consistently over time, suitability of data (in what form are they available?), and whether they can be integrated with other data sets.
- *Usability criteria* are concerned with whether the information is action-oriented, that is, whether it is useful to public health professionals, policy makers or the public to inform preventive action, programs or policy interventions. Important also is the number of people exposed, the number of people whose health is affected (mortality, morbidity, disability), including definition of vulnerable populations, and various measures of the cost to society of the exposure.

Which Indicators Should Be Considered for an Environmental Health Tracking System in Canada?

As an example, possible indicators for surveillance of particulate air pollution (PM_{2.5}) are presented in Table 2. Ambient levels of PM_{2.5} provide a consistent and useful indicator of hazard. Modelling shows that ambient air levels represent personal exposure levels reasonably well, although there is recent interest in exposure in micro-environments, such as proximity to traffic (Toronto Public Health 2007). The indicator is relevant to preventive policy interventions in transportation and urban planning, and in terms of individual behaviour change during smog alerts, but would require agreement on when and where to monitor, as street exposure levels do vary (Lebret et al. 2000).

The indicator for health effect surveillance has two possible measures: excess hospitalization, and excess mortality from respiratory and cardiac disease related to PM_{2.5}. The data are comprehensive across Canada, and data quality is assured. To calculate excess cardio-respiratory mortality and hospitalization related to PM_{2.5} on an ongoing basis, time series studies would need to be conducted. Many of these have been published, showing strong associations (Goldberg et al. 2003; Pope and Dockery 2006). The necessary time series calculation to differentiate excess deaths related to variation in PM_{2.5} makes this indicator more controversial in terms of sensitivity to small (but potentially widespread) effects, validity and representativeness. However, it has great policy relevance because of the potentially large preventable burden of

“attributable” illness – again, due to the possible high prevalence of exposure, even if the size of effect is small.

A third possible indicator, the Air Quality Health Indicator (AQHI), is at present under development. It would integrate environmental monitoring (air quality data on fine and coarse PM, ozone, carbon monoxide (CO), nitrogen dioxide (NO₂) and sulphur dioxide (SO₂) from the National Air Pollution Surveillance Network) and health surveillance data in a single indicator, which could be applied at a federal, provincial or municipal level (Health Canada 2006b).

Many other important environmental health issues would provide even more challenges in creating practical and robust indicators across the pathway from hazard and exposure to health effect and intervention. The PM indicators might be the closest we can get to a “gold standard.”

Challenges and Next Steps

The complexity of the relationship between environmental exposures and health, and the difficulties in tracking, especially in obtaining appropriate data on exposure, make this a significant public health challenge, but surely one worth tackling. The complex

There is a particular need for a long-term political and financial commitment from all levels of government to monitor environmental issues that affect health, and to provide trained staff to enforce the standards established.

technical and infrastructure issues that are central to the development of a successful tracking system lie beyond the scope of this paper. Moving forward on environmental health tracking in Canada will require ongoing collaboration not only among national, provincial, regional and local levels of government, but also between environmental and

health and other agencies, and it will require sustained financial and political commitment. There is a particular need for a long-term political and financial commitment from all levels of government to monitor environmental issues that affect health, and to provide trained staff to enforce the standards established. There will be challenges in selecting the most appropriate areas for indicator development and tracking, areas that ultimately will have “some reasonable expectation of intervention” (Teutsch 2000). But how can this vision be moved along?

In the United States, the CDC, through its National Network Implementation Plan (CDC 2006c) is leading the development of a tracking network that is building

the central infrastructure, including a central portal and network interfaces, and developing capacity in partners at federal, state and local governments and in academic and other institutions. It has promoted the selection of data and development of indicators by giving grants that fund cooperative projects to identify, organize and improve the quality of relevant data.

We suggest that the model in Canada should be similarly cooperative across levels of government. The initial development would be led by Health Canada and the Public Health Agency of Canada and supported with federal funding. But the early steps should include creating a cooperative governance structure including federal/provincial/territorial governments, with a central secretariat, and working groups to steer the various elements of the process. It would be important to involve health, environment and natural resources ministries at both the federal and provincial/territorial levels, as well as Statistics Canada. The initial projects might include a scan of already existing activities, a needs assessment from federal to local levels of government and development of a business case defining the benefits of an environmental public health tracking system to all levels of government. The business case should address how governments from federal to local would relate to the system, and the costs in terms of dollars, personnel and technology. Ongoing funding would need to come from all levels of government involved in and benefiting from the system, but the first steps would be the funding of pilot projects through academic institutions or environmental/health authorities to get the ball rolling and achieve some early successes.

Conclusion

An environmental health tracking system is considered a fundamental requirement for the effective practice of public health in Canada. We have attempted to focus the discussion by exploring a conceptual approach to the selection of the environmental and health issues most important to track, and discussing the example of an indicator – one that is virtually “ready to use” now (PM_{2.5} levels in air) – that would enhance the effectiveness of environmental health practice and policy. Other jurisdictions have begun the process of establishing environmental public health tracking systems. Canada is not far behind at the moment, and swift action on the part of government is appropriate.

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